Update on Wind-Diesel prospects in Nunavik

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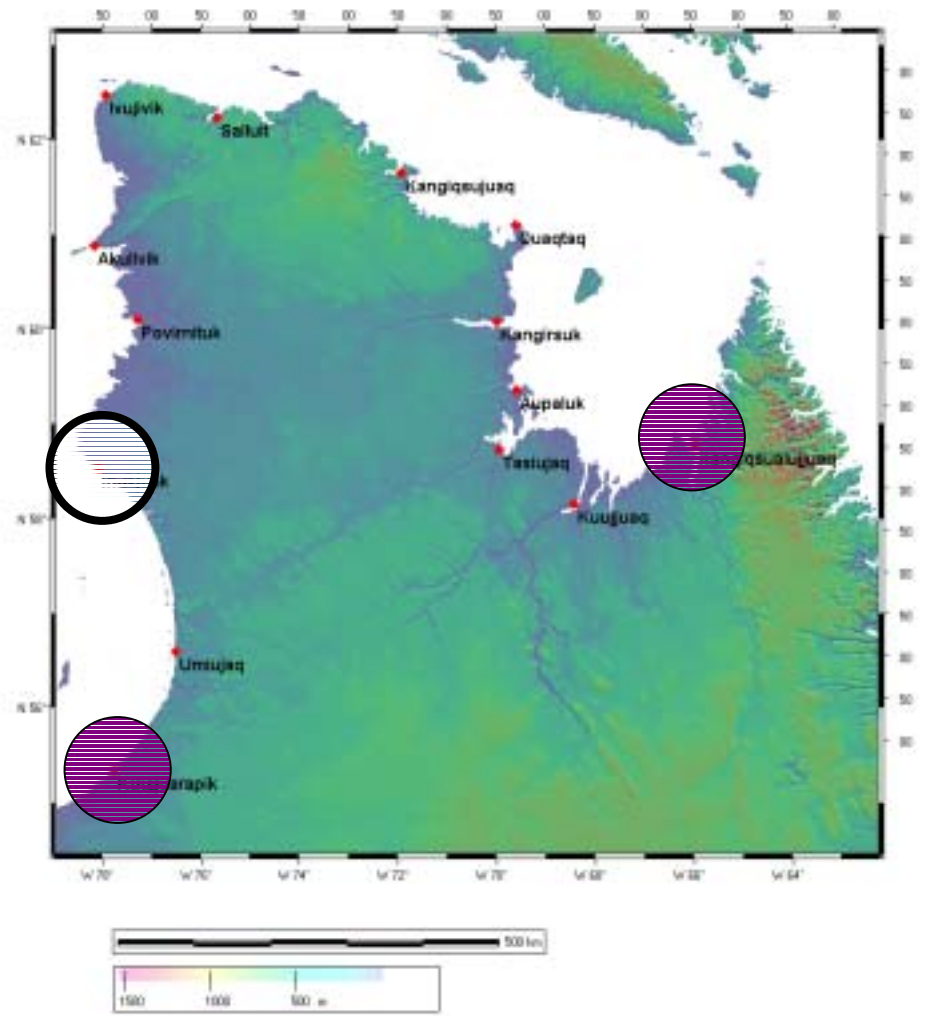
Update on Wind-Diesel prospects in Nunavik

1. **Rationale and background of HQ Wind-diesel activities (1985-2004)**

2. **Feasibility study (Avant-projet) for a first Nunavik project**
   - Showcase for HQ & Partners
   - RFPs: Wind resource, construction
   - Performance tracking



Technico-economic Summary

- It works
- It makes economic sense
- Ongoing (2004):
  - Feasibility of first implementation in a Nunavik village
- Partnership project

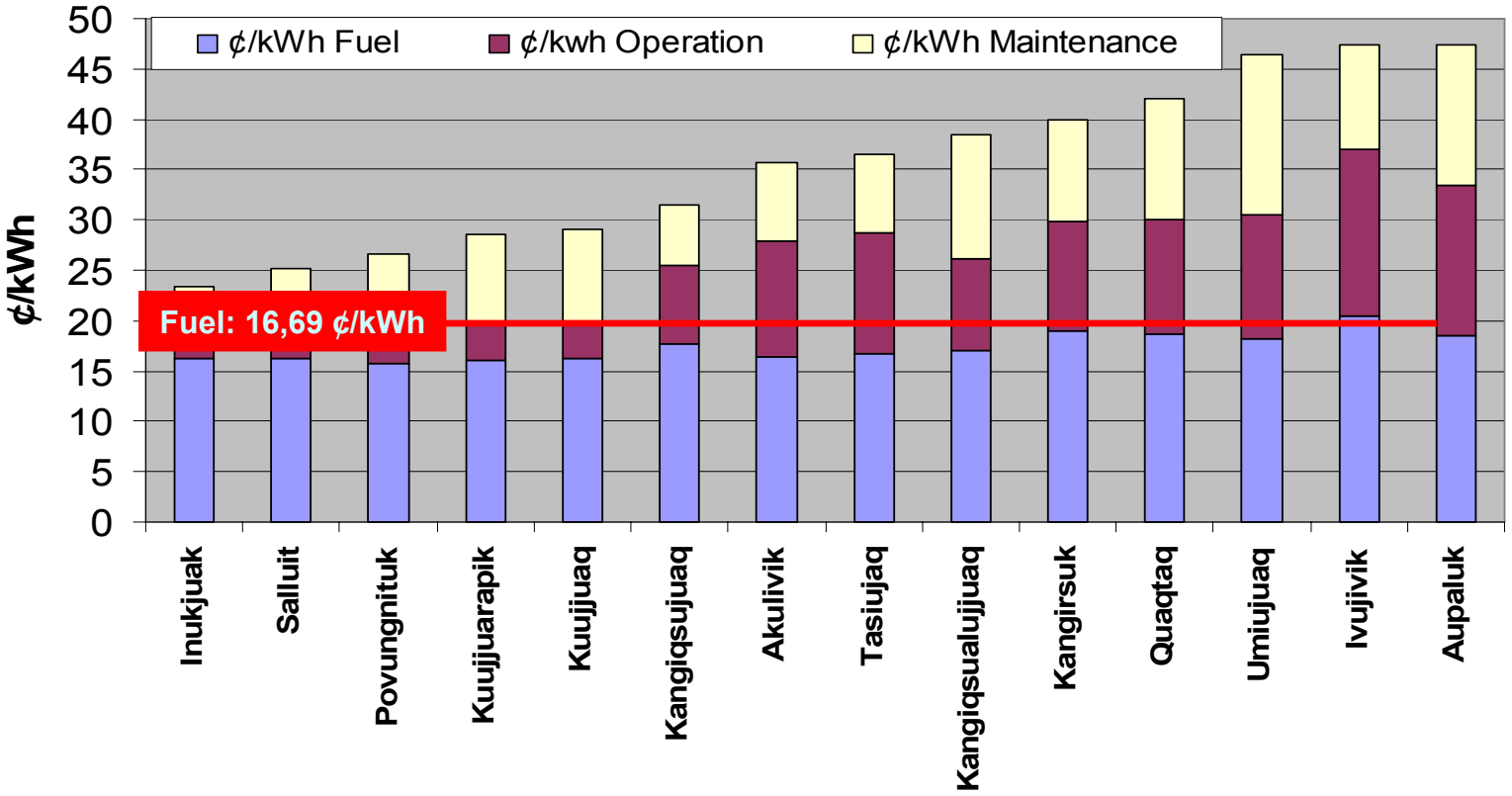
Wind-Diesel rationale for Nunavik

- **HQ Objective :**
  - **Reduce HQ annual operating deficit in Remote communities grid by implementing high penetration wind diesel technology in a first Nunavik village**

Some statistics

- Nunavik vs all of remote grids served by HQ
  - 45,1 of total annual purchases of fuel
  - 16,4 % of total annual sales of electricity
- Fuel represents 53,8% of the operating cost in Nunavik (~ 9,5 M$ in 2004)
- High-penetration Wind-Diesel technology could result in a ~ 50% decrease in the annual fuel purchases for all the inuit villages.

Production costs (charges) , Nunavik ($1997)



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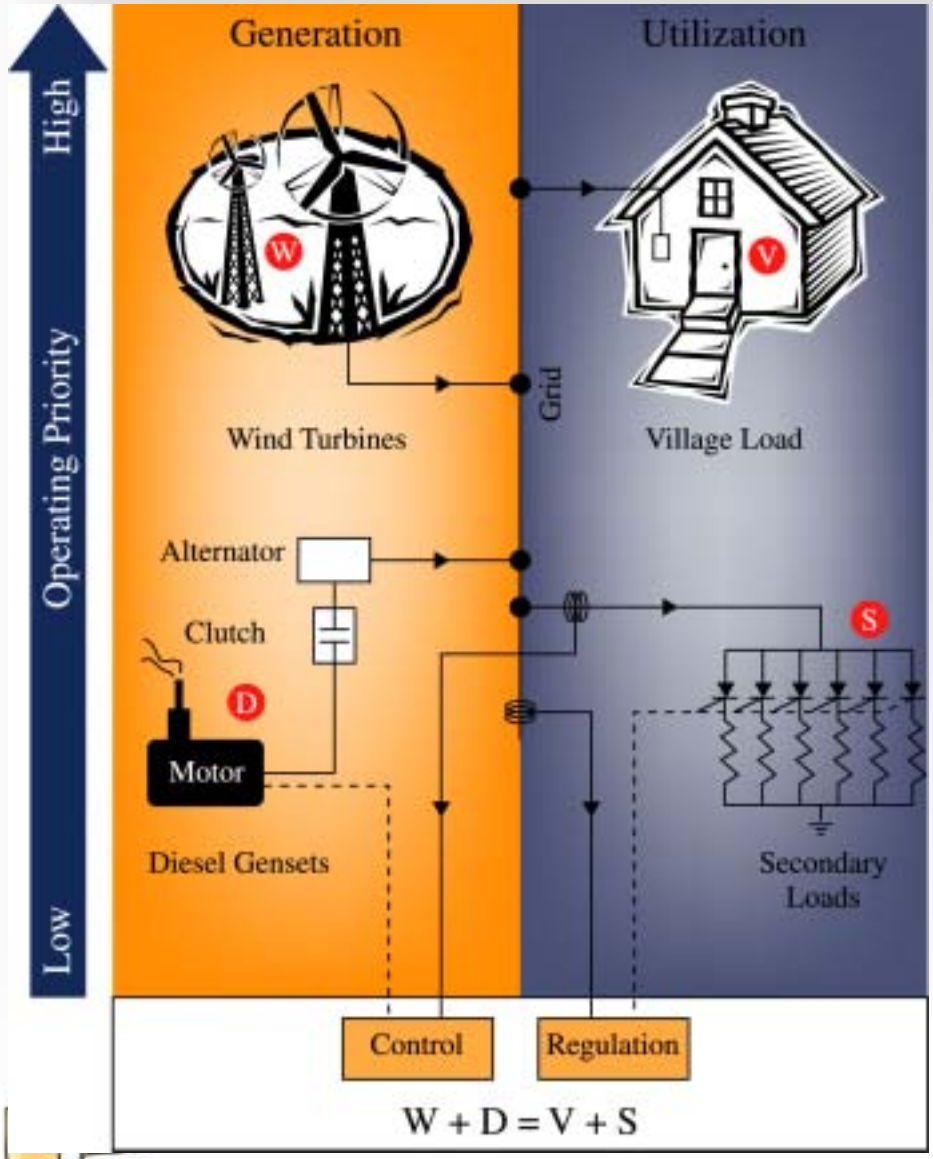
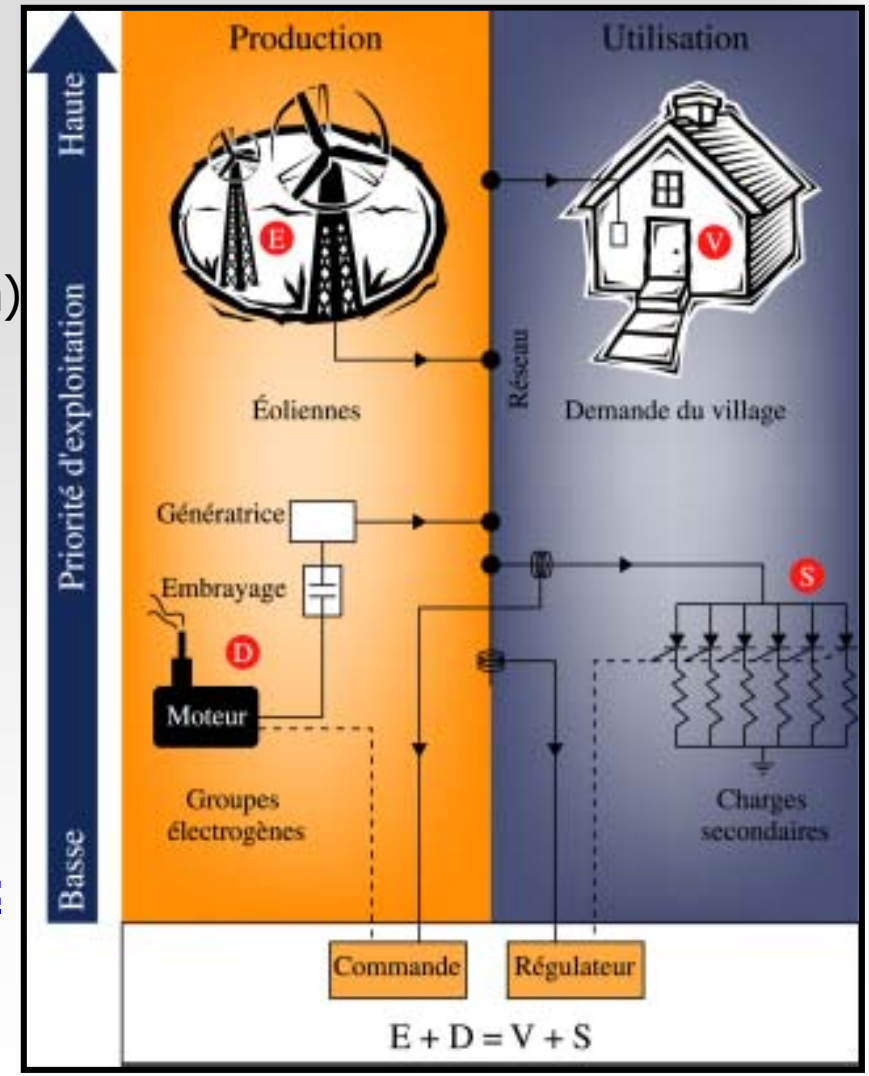
The High Penetration No-Storage Wind Diesel Concept



- **Priority to Wind Energy**
  - **Optimal Penetration Dictated by Economics**: Cost of Fuel, Wind Resource
    - Diesels Are Shut When Wind Exceeds Demand
    - Energy Surplus Used in Secondary Loads (added value)
- **No Power Quality Reduction**
  - A **Frequency Regulator** Maintains Balance Between Generation and Load
  - A **PLC Manages the Transitions** Between the Operating Modes: All-Diesel, All-Wind and Wind-Diesel
- **Savings**
  - Fuel: 40% and more depending on wind resource quality
  - Increased Diesel Life
  - Diesel Maintenance
- **Additional Costs**
  - Wind Turbine maintenance

High-penetration No-Storage Wind-Diesel (HPNSWD) - Milestones

- 1990: Modeling/experimental Validation
  - IREQ (partner NRCan)
- 1994: Demonstration
  - Atlantic Wind Test Site (partner NRCan)
- 1994-6 HQ Working group
  - Cost effectiveness (pre-feasibility) in 8 of the 14 Nunavik communities
  - *Implementation Recommendation aborted*
  - *Quaqtaq economic feasibility study*
- 1998 - **First commercial implementation : St-Paul island, Alaska**
- Contractor: **Northern Power Systems, Vt, USA**
- Technology & Consultant: **Hydro-Québec (IREQ)**



St. Paul Island, Alaska

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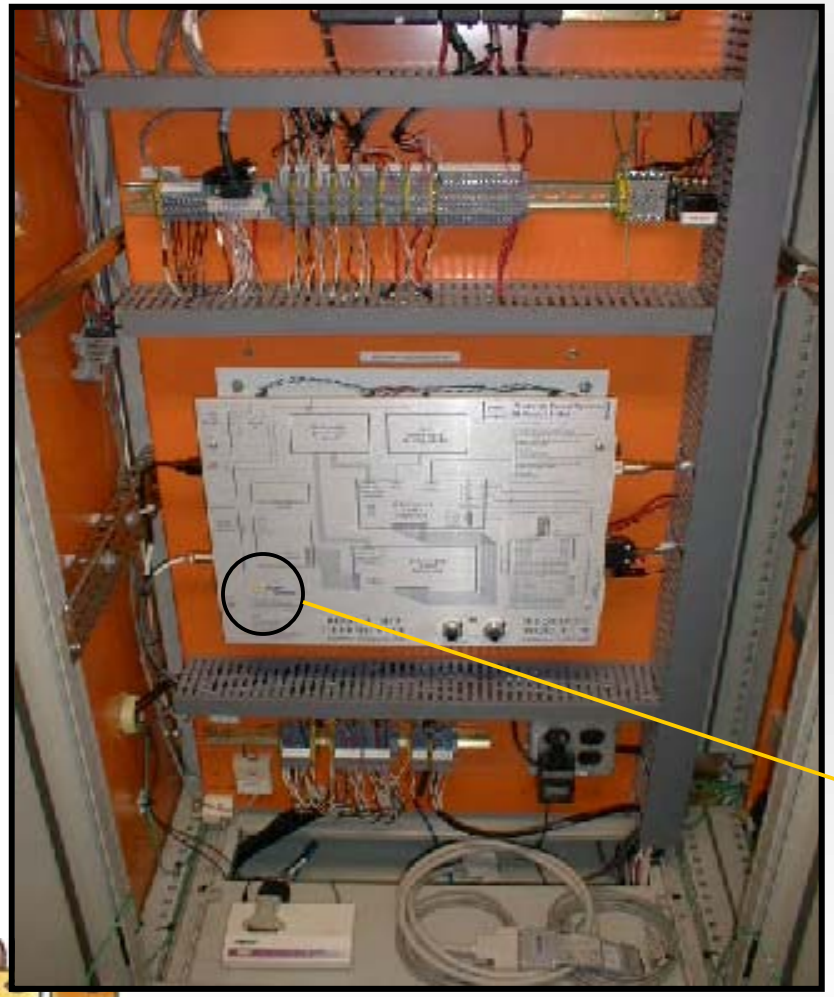
St. Paul, Alaska

Frequency regulator



Secondary loads (Surplus energy)

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Lessons learned from St-Paul Island, Alaska

- Turnkey construction is currently available
  - Full system (diesel & wind) appears cost effective
  - Commercial projet carried out by Northern Power Systems, Vt
  - Reliable contractors exist
- Technology and know-how: IREQ
  - Demonstrated cost-effectiveness (St-Paul, Alaska):
    - COE from 34 to 21 ¢US/kWh (new wind-diesel power station)
- In 2001: Decision to update 1996 & 1998 economic studies for Quaqtaq

Economic Studies Update (Quaqtaq)

- 2001- Northern Power Systems:

  Northern Power Systems, « Wind-Diesel Hybrid System for Quaqtaq, feasibility study, final report », august 2001

- *Réf: Saulnier, B. « Analyse et Recommandations découlant de l'actualisation 2001 des coûts de réalisation d'un système JEDHPSS clef en main au village de Quaqtaq, Ungava », Août 2001*

- Valuable features in upcoming projects
  - Wind technology performance and reliability (continuous decrease in COE, ¢/kWh)
  - Fuel cost will grow (deficit growth)
  - Cost of capital is kept low
  - Experienced contractors

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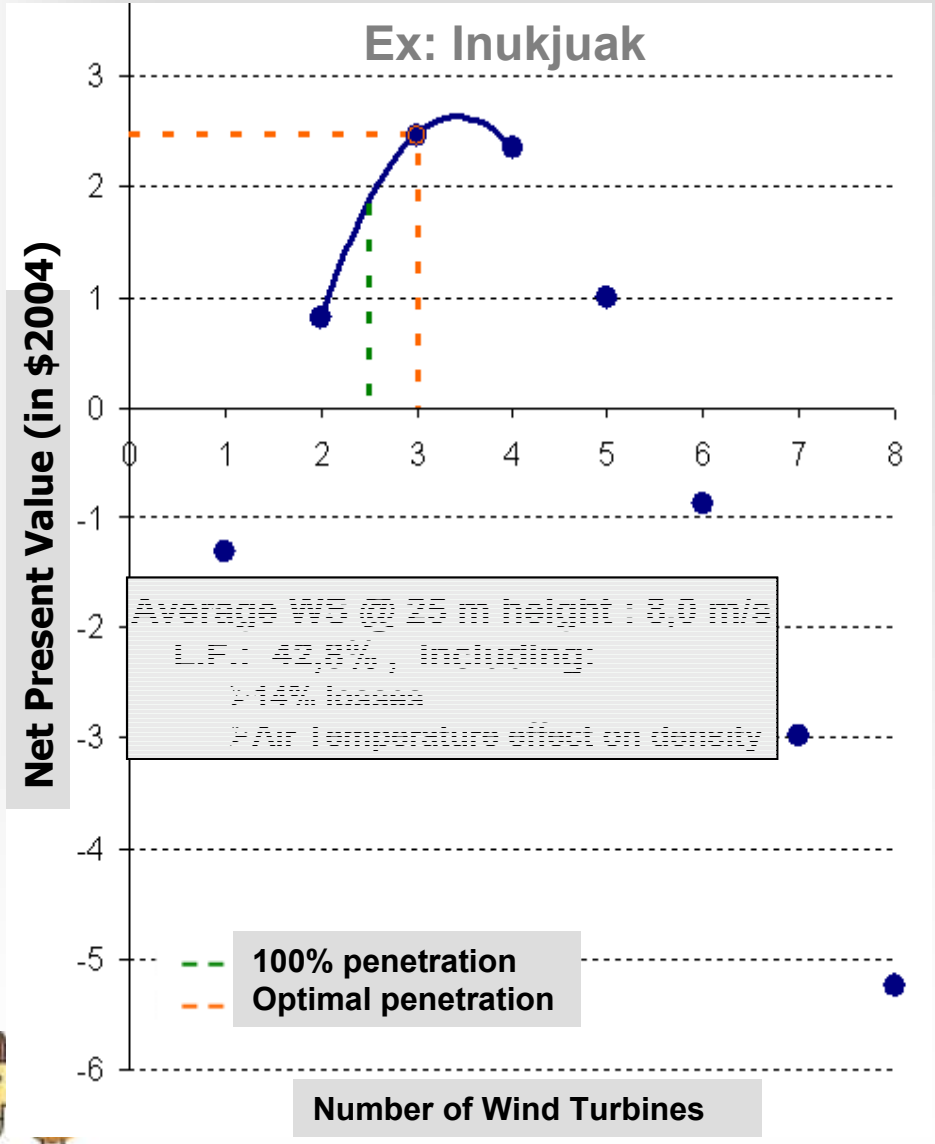
Need for an economic update for Nunavik 2002-3

- **2002- Reassess the NPV produced by HQ working group (1994-96) using most recent available data.**
  - Identify the most interesting Nunavik village for a first implementation of WD coupling.
  - Identify third-party integrator capable of completing a turnkey installation.
  - Partnerss: HQ-Remote grids, local authorities, constructor, project management, IREQ, financial partners
- Requirements and Constraints :
  - Community: Fuel supply through Shell vs Coop, Wind Turbine manufacturer (reliability and cost), Turnkey feasibility, Partnership /Technology Transfer, Project setup and organizational structure, Outside market
  - Operational requirements and constraints
  - Overall reliability (ex: harsh environment, cold, etc)

HPNSWD – Economic optimization



Parameters for each village

- Hourly demand of a whole year
- Diesel fuel consumption curve
- Fuel and maintenance costs
- + load growth forecasts
- Hourly winds at the wind power plant
- Commercial WT Costs
- Project life: 20 years
- Turnkey construction project
- Economic parameters (HQ-Réseaux)
  - Inflation
  - Real Discount rate
  - Project duration: 20 years
- Operational strategies parameters
  - Minimum diesel loading
  - Reserve criteria (high penetration)

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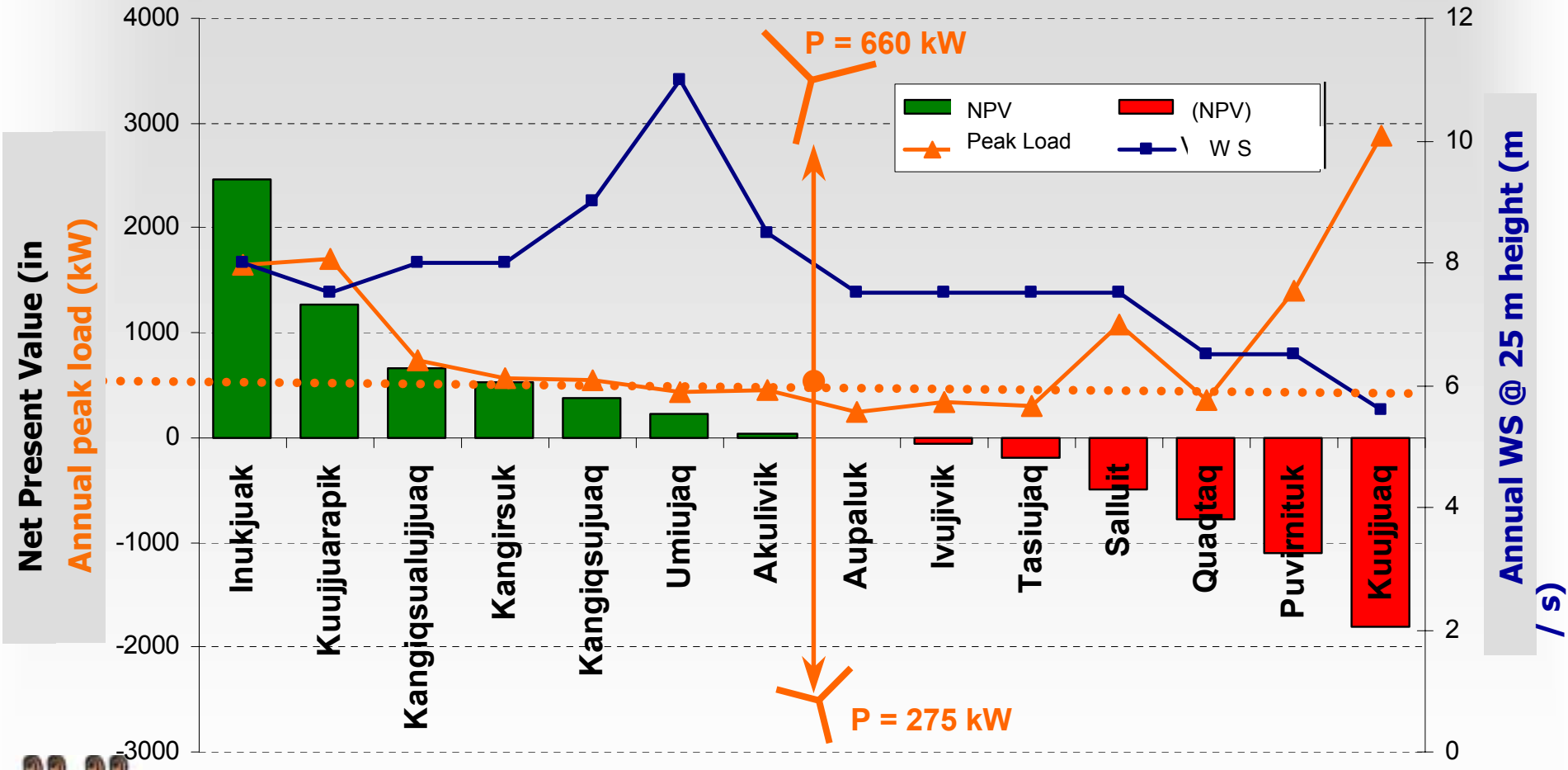
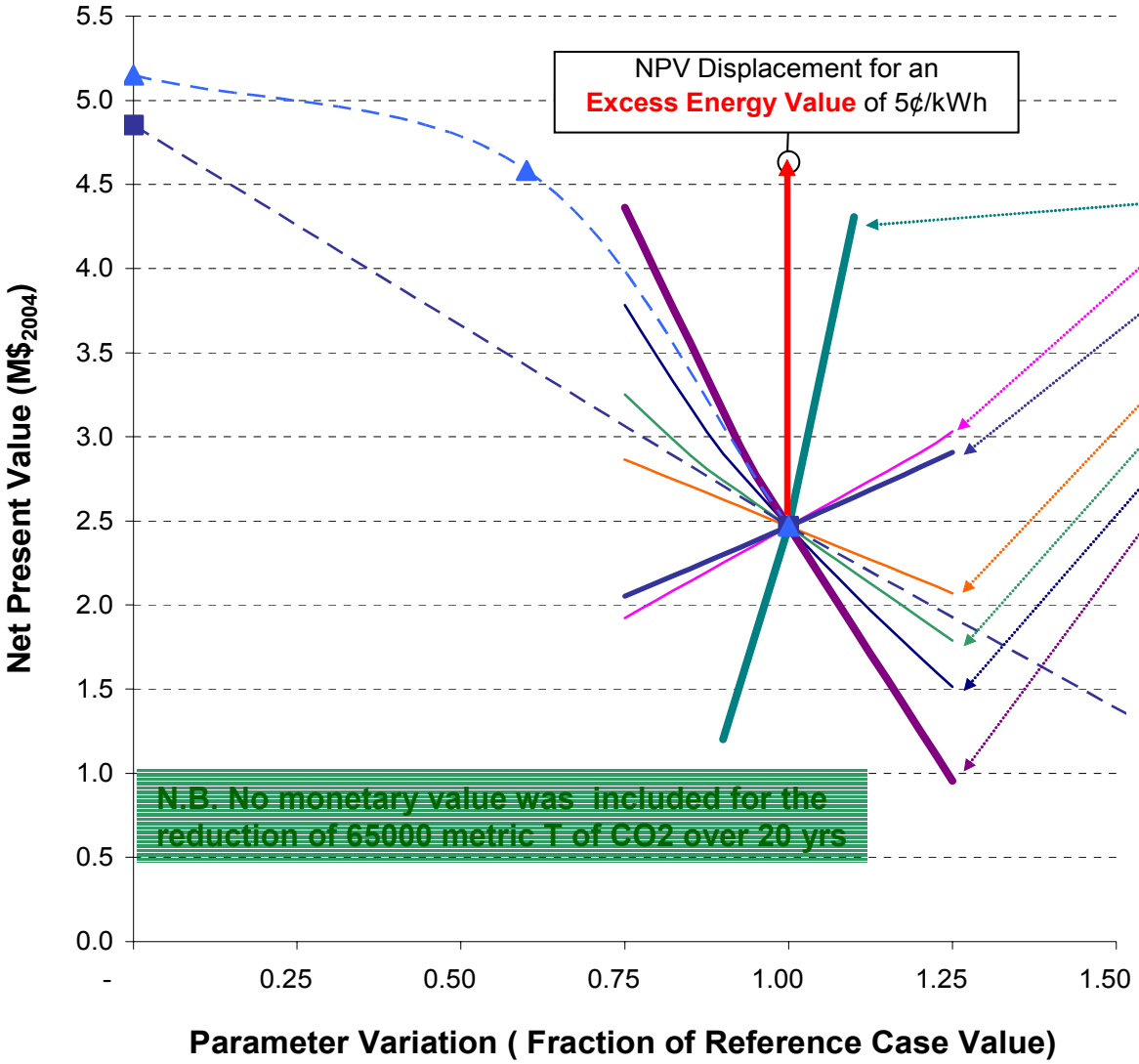
Overall Results - Nunavik

Ranking by maximum NPV for each village reference WD configuration

Discount rate: 5,2%

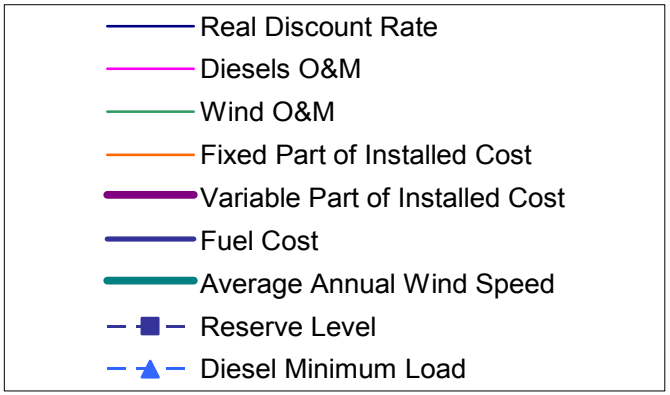


Sensitivity Study - Inukjuak



Reference case

- 3 x 0.66 MW turbines
- Project Duration: 20 years
- **Av. Ann. Wind Speed (at 25m): 8.0 m/s**
- Diesels O&M: 36.37 $/h
- **Fuel**: Average Δ_{annual} +2.1%
  (incl. inflation, 70.5 ¢/l in 2005)
- Fixed Part of Inst. Cost: 1670 k$
- Wind O&M: 3.0 ¢/kWh (210 k$/yr)
- Real Discount Rate: 5.20%
- **Variable Part of Inst. Cost: 2122 k$/kW**
- Excess Energy Value: 0.0 ¢/kWh
- Reserve Level: 10%
- Diesel Minimum Load: 50%



Project Feasibility Timetable

Internal cost effectiveness of HPWD in 7 villages

Inukjuak: Investment cost 9,28 M$; NPV 1,28 M$; IRR 7,0%

Technological maturity & reliability

Turnkey construction following an RFP process

- **Project is under stewardship of Dir. Rég. - Réseaux autonomes**

Phase A: On site wind resource monitoring (input to construction RFP) and RFP performance based write-up. Jan 2004 - Sept 2005

Phase B: RFP : turnkey construction and commissionning (2005-2006)

Phase C: Performance evaluation ; Technology Transfer

Partnership/Stakeholders involvement

- HQ - Remote grids / HQ-Distribution (owner and operator)
- Nunavik and local Authorities
- Third party contractors (WT mfg, system integrator, construction, performance monitoring)
- Federal partners : RNCan, INAC,
  - TEAM & WPPI programs
  - Innovative Technology Replicability
- IREQ (system specifications, performance track record)

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Project Strengths

- **Favourable factors**:

WT: Proven commercial products

- ✓ Industry workhorse
- ✓ Performance and reliability track record in northern climates

Feasibility of commercial operation demonstrated

- ✓ Alaska: St-Paul Island, Kotzebue, Selawik
- ✓ Antarctica: Mawson

Experienced commercial system integrators:

- ➢ NPS, Power Corp, Frontier energy Inc., DanWind, DanVest,

- **Added value for HQ & partners**:

Recognized world leadership in HPNSWD technology

Technology showcase: National & international market (via E7)

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HQ- IREQ Technology support:
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